Automatic Calibration (AUTO CAL) Process Drift Correction (Zero Shift) Sentinel B-21, I-21, and C-20

The Sentinel pressure or vacuum decay instruments test parts for leaks by pressurizing or evacuating a sealed part to a specified test pressure, stabilizing the pressure, and measuring the pressure change over a fixed test time. It compares this measured pressure change to parameters determined within an AUTO CAL routine. The AUTO CAL routine tests a non-leaking part and the non-leaking part with an NIST traceable leak orifice. The instrument measures the typical pressure change for the non-leaking part and determines the ratio of the pressure change difference of the second test minus the first test verses the known leak rate value of the calibrated orifice. The two-test Auto Cal routine determines two important values:

1) **Typical pressure change for a good part** (dPnoLeak) at the time of calibration due to slight volume changes, temperature changes, or air absorption during the test cycle.

2) **Volume of the test system pneumatics and test part (Volume)** or the proportional relationship of pressure change to leak rate for the specific part and test pneumatics under test.

These two important measured and calculated values are stored digitally in the instrument's memory and will not change over time. The formula that relates the measured pressure change to a Leak Rate is as follows:

$$\text{Leak Rate} = \frac{(\text{Volume}) \times (dP_{measured} - dP_{noLeak}) \times 60\ \text{sec}}{(\text{Test time}) \times 14.7\ \text{psi}}$$

Leak Rate is stated as **sccm** (standard cubic centimeters per minute).
Volume which includes part and test circuit volume is stated as **cc** (cubic centimeters).
Test time is stated in **seconds**.
dPmeasured and **dPnoLeak** are stated in psi.

After the instrument is properly calibrated, it assumes that the part and test circuit volumes are constant within a small band of variability ($\pm 2\%$). Initially after calibration the measured pressure change values for the non-leaking parts should match the dPnoLeak value within a small band of repeatability (± 1 to10%) depending on sufficient cycle time and part repeatability.

Cincinnati Test Systems, Inc.

Process Drift Correction (Zero Shift)

The actual measured pressure change for typical non-leaking parts will drift during the production day due to changes in the manufacturing process like temperature and part material characteristics. As a result the calculated leak rate test results will change over the day. If the amount of drift in the leak rate results is unacceptable, the user has the option to re-calibrate the instrument as frequently as necessary to track the unacceptable drift in test results or activate a standard function within the Sentinel B-21/I-21/C-20 that will automatically track the drift and correct the calculated leak rate. This correction function is called Process Drift Correction or Zero Shift. It does not correct for part-to-part temperature changes caused by randomly testing cold or hot parts.

In the Sentinel I-21/B-21 this function is called Zero Shift. The Sentinel C-20 has an equivalent function called Process Drift Correction. These functions track the small variations in pressure change due to process drift. If these correction functions are activated (selectable within part parameters), they will compare each pressure change that falls within a defined pressure change band about the dPnoLeak value for a pattern of drift. The function calculates any shift of the measured pressure change values (within the defined pressure change band about the dPnoLeak value) from the dPnoLeak value and corrects the readings for the average shift.

Leak Rate =

$$\frac{(\text{Volume}) \times (dPmeas - dPnoLeak + dPprocDrift) \times 60 \text{ sec}}{(\text{Test time}) \times 14.7 \text{ psi}}$$

This function keeps the instrument's calibration tuned to the process which includes changes in fill-air temperature, part temperature, ambient temperature, part elasticity, part absorption, and seal creep.

Before activating Process Drift Correction (Zero Shift) it is usually best to download a day's production test results and plot them out to see just how much drift does occur. The Sentinel B-21/I-21 instruments store up to 1000 test results. The Sentinel C-20 instruments store up to 500 test results. These test results can be downloaded via the RS232 port to Windows "Hyperterminal" or to CTS Talk (Sentinel B-21/I-21 only). A time plot of the test results will show the cyclical effects of the process drift on the test results. Also the magnitude of the drift can be evaluated to see if it adversely affects the test results.

The "Press Loss" values Figure 1 show a clear pattern of drift due to process variable changes. As a result of the drift two parts were rejected. When the pressure change values are corrected by the calculated "Zero Shift" as shown by "AdjPressLoss", these two parts actually had pressure changes that were less than the Hi Limit Loss. In this case process drift correction would reduce the number of parts that are rejected.
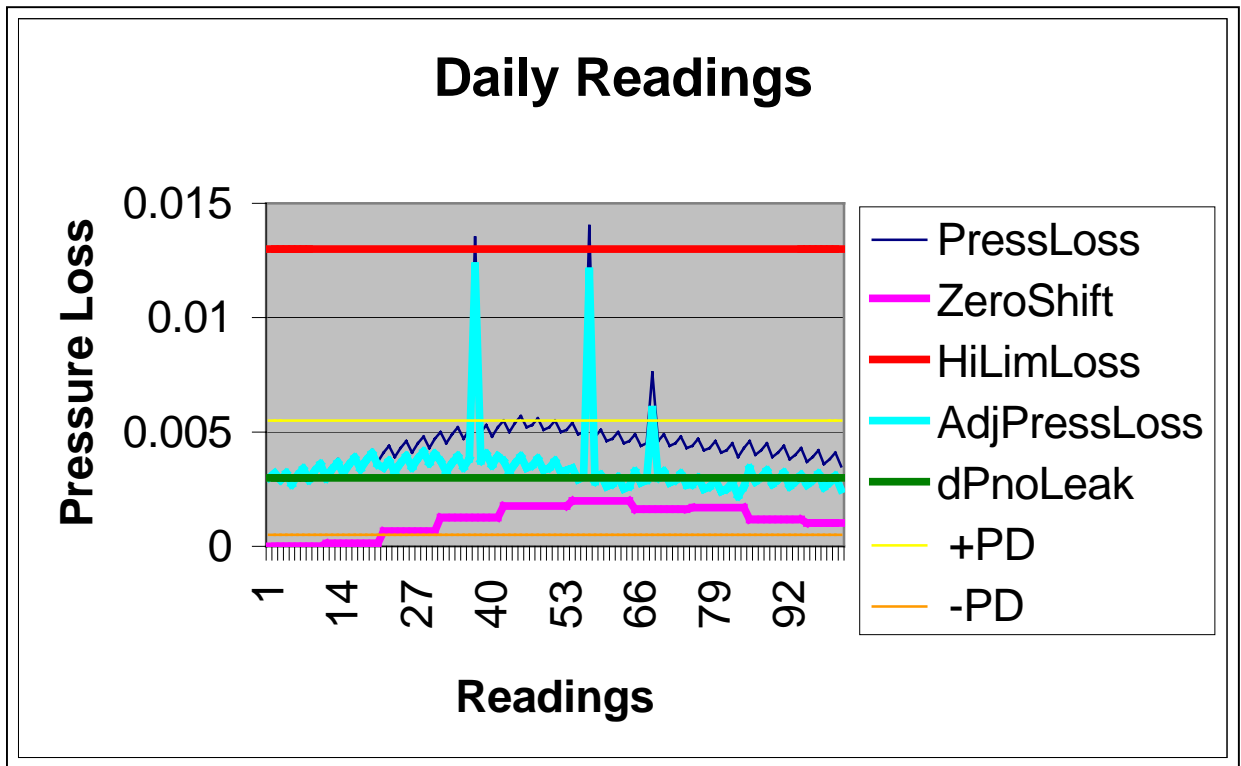
Figure 1 Plot of test results, calibration limits, zero shift band, and corrected leak rate results
(Zero Shift, for this example, calculated the average of 10 readings within the ±PD band.)
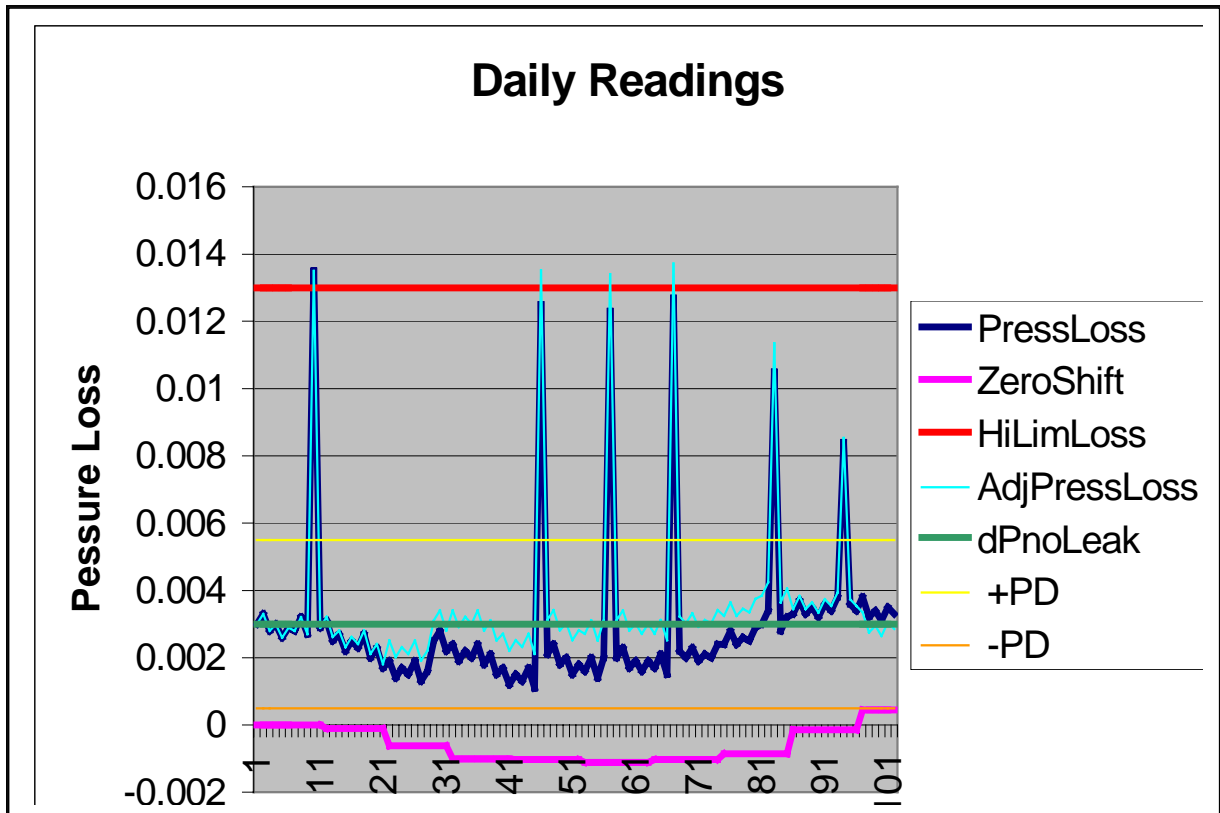

Figure 2: Plot of test results, calibration limits, zero shift band, and corrected leak rate results
(Zero Shift, for this example, calculated the average of 10 readings within the ±PD band.)

The "Press Loss" values above again show a clear pattern of drift due to process variable changes. As a result three parts were accepted that should have been rejected. When the pressure loss values are corrected by the calculated "Zero Shift" as shown by "AdjPressLoss", these three parts are properly rejected. In this case process drift correction helped the instrument catch three defective parts that would have passed without re-calibrating the system.

After analyzing the typical pressure change values over a typical production day and determining that most of the pressure loss changes occur in a cyclical fashion, Process Drift Correction or Zero Shift can be used to nearly eliminate performing Auto Cal to keep the instrument tuned to the process. An occasional calibration verification will show that the system is accurately reading the leak rate.

Calibration Verification

To confirm that the instrument is correctly calibrated, it is easy to perform a periodic test on a master or good part with a traceable leak added to it. The Sentinel instruments have an NIST traceable orifice mounted on the internal pneumatic manifold. This is the orifice that is used in the AUTO CAL routine. The orifice isolation valve can be manually opened by the operator in order to add the orifice to the pneumatic test circuit. The control of the orifice isolation valve is accessible through the SELF TEST button. When testing a master or good part with the internal orifice added to the test circuit, the instrument display should read the orifice valve within a ± 1 to 10% tolerance. This reading will include the process drift correction and should indicate that the testing process is in control. The calibration isolation valve should be closed after performing this test.

Using Process Drift Correction or Zero Shift will:
- **Maintain system accuracy throughout the production period and therefore provide better test results**
- **Improve production throughput by eliminating production downtime for frequent re-calibrations**
- **Minimize the opportunity to improperly calibrate the system**
- **Improve confidence in leak testing by reducing false rejects and accepts.**
- **Minimize confusion for operator by reducing the drift of test results above and below zero leak during the production day.**